Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Investigation of the Spectrum Requirements for Advanced Medical Technologies	)	ET Docket No. 06-135
	)	
Amendment of Parts 2 and 95 of the Commission's Rules to Establish the Medical Device Radio Communications Service at 401-402 and 405-406 MHz	)	RM-11271
	)	
DexCom, Inc. Request for Waiver of the Frequency Monitoring Requirements of the Medical Implant Communications Service Rules	)	ET Docket No. 05-213
	)	
Biotronik, Inc. Request for Waiver of the Frequency Monitoring Requirements for the Medical Implant Communications Service Rules	)	ET Docket No. 03-92

EX PARTE COMMENTS OF GE HEALTHCARE

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INTRODUCTION AND SUMMARY

GE Healthcare ("GEHC") hereby submits the following *ex parte* comments in the above referenced proceeding to expand upon its previous proposal 1/, made in response to the Commission's Notice of Inquiry 2/, for a spectrum allocation (allowing operations on a secondary basis) to support body sensor networks ("BSNs"). In its comments, GEHC described the significant potential benefits of BSNs – very short-range networks consisting of multiple body-

1/ *See* GEHC Comments (filed Oct. 31, 2006); GEHC Reply Comments (filed Dec. 4, 2006).

2/ *Investigation of the Spectrum Requirements for Advanced Medical Technologies*, Notice of Proposed Rulemaking, Notice of Inquiry and Order, ET Docket No. 06-103, 21 FCC Rcd 8164 (rel. July 18, 2006) ("*NPRM/NOI*").

worn sensors/nodes and a nearby hub station. Such networks would replace the tangle of cables that today act to tether most hospital patients to their bedside monitoring units and frequently result in disconnected sensors. GEHC also explained why the existing MICS/proposed MedRadio, WMTS, and unlicensed Part 15 regimes are not well suited to BSN operations. 3/ In its reply comments, GEHC identified a number of bands as candidates for allocation to a new service supporting BSNs. In this submission, GEHC proposes detailed service rules that would apply to BSN operations in the 2360-2400 MHz band, and that define the regulatory status of BSN operators, permissible communications and emission types, emission bandwidth and power limits, spurious emissions limits, license eligibility, licensing and certification requirements and channel use policies, including the use of contention-based protocols to promote co-existence with other services.

I. WIRELESS BODY SENSOR NETWORKS HOLD GREAT PROMISE FOR IMPROVING THE QUALITY AND EFFICIENCY OF HEALTH CARE

GEHC believes that recent advancements in wireless technology make it possible to use wireless as never before in the delivery of health care services. One of the most promising concepts on the horizon is that of the body sensor network, which has been an area of considerable research recently. 4/ At its essence, a BSN is created through the attachment of multiple low cost sensors or network nodes at different locations on or around the body. These sensor/nodes take readings of key patient-specific information, such as temperature readings, pulse readings, blood glucose level readings, electrocardiogram readings, blood pressure level readings and readings

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3/ GEHC Comments at 7-11.

4/ *See, e.g.,* www.bsn-web.org, www.ubimon.net, www.pervasive.ifi.lmu.de/adjunct-proceedings/demo/p077-080.pdf, www.eecs.harvard.edu/~mdw/proj/codeblue, www.healthcare.pervasive.dk/ubicomp2004/papers/final_papers/laerhoven.pdf, pubs.doc.ic.ac.uk/sensor-monitoring-operative/sensor-monitoring-operative.pdf, www.toumaz.com/products/sensium.htm.

relating to respiratory function. Antenna components embedded in the sensor/nodes make it possible for the data generated by the sensor/nodes to be transmitted wirelessly to a body-worn or closely-located hub device, eliminating the need for cables. The hub device, in turn, receives the data generated from the various sensor/nodes on the body and may process the data locally and/or transmit it wirelessly via an appropriate radio link for centralized processing, display and storage.

Most current bedside monitoring solutions pose well-known burdens to clinicians. The presence of cables, catheters, and tubing connecting the patient and sensors to the instrumentation can diminish productivity and the quality of patient care. For example, rotating a patient to alleviate bedsores or ambulating a patient about a hospital room can be problematic if one is saddled with tethered devices. Procedural delays stemming from cable management also contribute to a greater percentage of time dedicated to routine, mundane tasks not directly related to treatment of the patient's illness.

This longstanding problem has remained unsolved for a variety of reasons. A major problem involves the varying levels of care that a patient might receive during a stay in the hospital. A single patient, for instance, could easily progress from low-acuity monitoring at the admissions stage to high acuity monitoring within a specialized care unit, to a lower acuity level involving ordinary cardiac telemetry, and finally to discharge. To meet this need of evolving care, a variety of instrumentation has been developed to accommodate the monitoring needs. These monitoring instruments can be added or subtracted from the patient's monitoring regime, depending on the patient's needs. However, these adaptive needs only add to the burden of cable and device management.

Wireless communication technology that is tailored to patient monitoring would alleviate many of the problems (e.g., limited patient mobility and comfort and the risk of intentional or accidental cable disconnections) associated with current device management and cable clutter, making the provision of patient care safer and more efficient.

Among the probable benefits of BSNs are increased patient comfort and mobility, more holistic monitoring, reduced risk of infection and improved caregiver effectiveness. In addition, the potential for unprecedented flexibility of parameter scalability could enable much more widespread deployment of effective and efficient monitoring solutions. BSNs thus promise more comprehensive and pervasive physiological monitoring both inside and outside of healthcare facilities.

Although multi-parameter patient monitoring occurs today, hospitals and health care facilities are limited in their ability to take full advantage of such monitoring. The current approach requires that a high cost monitoring unit be assigned to every patient and severely limits the number of patients who can be served effectively by health care professionals making use of the technology. If reliably and effectively implemented, BSNs could help reduce significantly the costs associated with patient monitoring. By allowing more of the unprocessed patient data to be sent to a centralized location, BSNs could allow hospitals and health care facilities to replace the expensive bedside units (with dedicated processing capabilities) they currently use with much lower-cost systems. 5/ Although this "centralization" of data is furthered today by the use of medical telemetry systems, most medical telemetry systems are not capable of handling and adjusting to multiple acuity environments. By contrast, BSNs would be able to easily accommodate additional sensors to measure additional patient vital sign readings. Moreover, usage of BSNs outside the hospital could also help to reduce overall health care costs, especially

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5/ There will likely still be a need, however, for some more sophisticated BSNs which process the data and perform alarm functions locally.

among chronic disease patients 6/ who are capable of receiving care at home. 7/ For example, if a downward trend in a patient with chronic heart failure could be detected before the patient's condition became too severe, then intervention could occur in a less costly manner and/or setting (*e.g.*, a trip to the emergency room or ICU could be avoided).

Another benefit of BSNs is the greater spectrum efficiency that can be achieved through the BSN approach. Traditional telemetry systems generally create a separate RF link to the remote monitoring station for each patient sensor. BSNs utilize network bandwidth more efficiently by creating a very short range point-to-point wireless network, thereby enabling greater spectrum reuse. The BSN hub can then efficiently backhaul the data from multiple sensors to the monitoring station using a single longer-range (*e.g.*, WMTS) RF link.

II. BROAD SUPPORT EXISTS FOR THE ALLOCATION OF ADITIONAL SPECTRUM TO SUPPORT NEW MEDICAL DEVICES AND APPLICATIONS

The record in this proceeding reflects broad support for the allocation of additional spectrum for new wireless medical devices. A number of commenters joined with GEHC in highlighting the need for additional spectrum. As Medtronic stated, "now is the time to identify possible additional spectrum bands to support future advanced wireless medical uses, as the communications needs of medical devices will expand greatly in the coming years." 8/ Partners Healthcare System ("Partners") reported that its WMTS systems are at maximum capacity and that unlicensed devices are also facing capacity constraints as they proliferate within the hospital

6/ Eighty percent of the nation's healthcare dollars are spent is on twenty percent of the patients. A large portion of these patients have chronic diseases.

7/ The BSN could travel with the patient at hospital discharge and continue to be used to monitor the patient from home. In addition, if the patient were to be transported via an ambulance the BSN could be used to provide vital signs monitoring within the ambulance.

8/ Medtronic, Inc. Comments at 17.

setting. 9/ Partners also raised quality of service concerns given that both WMTS and unlicensed devices have experienced harmful interference and require "active management" with regard to the number and types of devices operating. 10/ The Alfred Mann Foundation ("AMF"), like GEHC, called for additional spectrum specifically to support new devices that cannot be accommodated in the 401-406 MHz MedRadio band. AMF explained that licensed WMTS and Part 90 spectrum above 450 MHz is too congested and populated with commercial, high-power systems that could preclude the operation of lower-power wireless medical devices, and the emissions limits for unlicensed operations are too restrictive to permit the kind of wideband microstimulator devices AMF is developing. 11/

To ensure that any newly-allocated spectrum can be used effectively, flexibly and efficiently, GEHC suggested in its comments that some type of spectrum sharing protocol be adopted that could promote device coexistence and a predictable quality of service. Other commenters made similar recommendations. For example, Partners urged the Commission to "require device manufacturers to develop industry standards, similar to the IEEE 11073 Medical Device Communications efforts, to ensure coexistence between device communications protocol." 12/ Medtronic and Intel also expressed support for a spectrum protocol or industry standard. 13/

9/ Partners Healthcare System, Inc. ("Partners") Comments at 2-3.

10/ *Id.*

11/ Alfred Mann Foundation ("AMF") Comments at 10-11.

12/ Partners Comments at 7.

13/ *See* Medtronic Comments at 13 (stating that a protocol is "required to support a necessary level of communications reliability for short range medical applications"); Intel Comments at 6.

In addition to GEHC, a number of other commenters noted industry efforts underway to develop body-worn wireless sensors. 14/ To be viable, the body-worn sensors must be very low cost devices which, as AMIS notes, will reduce health care costs while improving care to patients. 15/

III. KEY CONSIDERATIONS FOR NEW SERVICE TO SUPPORT BODY SENSOR NETWORKS

In order to be universally applicable through all levels of acuity, BSNs must be capable of reliably conveying unprocessed life-critical monitoring data to devices that are responsible for processing and primary alarming. In these scenarios, if the link is lost, a serious event such as arrhythmia or hypoxia could go unalarmed. Therefore, wireless quality of service ("QOS") will be a critical consideration for BSN design. BSNs must be able to provide reliable communications on and in the immediate vicinity of the patient's body.

Also, as noted above, the commercial acceptance of BSN devices will depend on whether manufacturers can produce small low-cost (*e.g.*, low enough to be disposable in some cases) sensors, which in turn will depend on the manufacturers' ability to leverage low cost, off-the-shelf integrated circuits that can preferably be used directly or at least that can be modified or adapted at relatively modest cost and complexity (*e.g.*, minimal external discrete circuitry). This electronic component consideration therefore limits the number of potential bands where BSNs

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14/ *See, e.g.*, Medtronic Comments at 6 (referencing "Body Area Networks"); AMI Semiconductor, Inc. ("AMIS") Comments at 2 ("many developers are investigating the incorporation of body-worn sensors to monitor patients' vital signs, eliminating a wired connection and providing additional patient mobility"); Intel Corporation ("Intel") Comments at 4 (noting advantages of wireless sensors).

15/ AMIS Comments at 4. Ideally, devices would be sufficiently low cost to be regarded as disposable devices, thereby eliminating the need for sterilization between uses, as AMIS notes. *Id.*

can be deployed to bands where radio chips are already operating or bands near such already operating bands.

BSN devices must also be capable of relatively long continuous operating times (*e.g.*, several days) while continually communicating physiological waveform data. This requirement, coupled with the size and cost constraints for BSN sensors, implies very low power consumption.

A further implication of the constraints on cost, electronic complexity and power consumption is that the choice of modulation type is likely to be limited to simple techniques such as binary frequency shift keying ("2-FSK"), since more spectrally efficient, higher-order modulation techniques are likely not feasible due to the various constraints mentioned above.

Similar to next generation medical devices being developed by the Cleveland FES Center ("Cleveland"), 16/ BSNs would be a high bandwidth / low latency application with high reliability requirements. GEHC estimates that in order to be generally effective throughout the range of clinical acuities, BSNs would have to support application data throughput of several tens of kilobits per second. In order to meet reliability requirements, this data rate would have to be increased through techniques such as forward error correction ("FEC"), cyclic redundancy check ("CRC") and automatic repeat request ("ARQ"). Given these data rates, the need to maintain a relatively low duty cycle to limit power consumption and the need to utilize low-complexity modulation techniques (*e.g.*, 2-FSK), the BSN symbol rate would be relatively high (*e.g.*, approximately one megabit per second) and channel bandwidth would be correspondingly wide (*e.g.*, approximately one megahertz). With such channel size, however, spectrum reuse becomes an issue. In order to avoid capacity constraints within high patient-density facilities such as hospitals, at least 20 megahertz of spectrum will need to be available for BSN communications at

16/ Cleveland FES Center ("Cleveland") Comments at 1-2.

any given time and location. Since BSNs would operate opportunistically on a secondary basis, the Commission should allocate a quantity of spectrum large enough to ensure that the frequency agile BSN devices will be able to avoid frequencies in use by other licensees and still be able to access at least 20 megahertz of clear spectrum within the allocated band(s).

The BSN concept involves a multitude of independent, mobile “pico networks” – one for each patient being monitored – which provide “cable replacement” for sensors and other devices attached to individual patients. BSNs must therefore be autonomous and frequency agile, *i.e.*, capable of sharing and reusing frequency automatically as dictated by patient movement, without traditional static FDMA channel assignment, manual frequency coordination or other centralized coordination schemes.

BSN operations should not be limited to the confines of hospitals, as application outside the hospital (*e.g.,* in ambulances and even home monitoring) are likely to become important. However, limitation of a subset of the requested spectrum to health care facilities, in order to ensure coexistence with radio astronomy, would be acceptable since the full allocation is likely to be required only in such facilities, where the highest usage densities will occur. For the purpose of such operational limitation, health care facilities should be defined to include hospitals, assisted living facilities, physician offices, ambulances and any other environments in which duly authorized health care professionals monitor, diagnose and treat patients.

Finally, in many cases, a BSN hub unit may use WMTS or other spectrum to “backhaul” the data it has received from the local sensor/nodes to a central monitoring station or other remote location. Therefore, it is desirable for BSN spectrum to be significantly separated from these bands to reduce implementation issues (*e.g.*, receiver blocking performance, etc.) related to simultaneous transmission and reception in the same device.

IV. DETAILS OF PROPOSED SERVICE

GEHC requests that the Commission establish a new Medical Body Area Network Service (MBANS) as a new subpart (subpart M) under Part 95. Appendix A contains specific proposed rules that would establish the MBANS consistent with the considerations described above. Some important aspects of the new rules are described below.

Permitted operations. The allocation and service being requested here would not be limited specifically to the BSN devices envisioned by GEHC, as other low-power short-range medical devices would also be permitted. However, due to the importance of preserving capacity in the band, permitted devices would be limited to those involved in the monitoring, diagnosing or treatment of a patient, as was also recommended by Partners and Intel.17/

Eligibility. MBANS operations would be licensed by rule for physicians and other healthcare professionals authorized under state and federal law to use, or to prescribe the use of, prescription medical devices, as well as for patients at the direction such authorized healthcare professionals.

Authorized locations. The proposed rules would allow mobile use without restriction to health care facilities or other geographic areas in a 20 MHz subset of the spectrum allocation. This would provide significant flexibility, including, for example, the flexibility for the devices to be used in patients' homes as envisioned by GEHC and several other commenters. 18/ The proposed rules would allow non-aeronautical mobile use in the remaining 20 MHz spectrum subset at health care facilities only, to facilitate coexistence with radio astronomy operations at

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17/ *See* Partners Comments at 5, 7 (noting that eligible devices should be those regulated by the FDA); Intel Comments at 5.

18/ *See* Partners Comments at 4 (noting need for home-based monitoring); Intel Comments at 4-5 (operation at home and by patients should be permitted); NDI Medical Comments at 2 (urging the Commission not to limit use to clinical settings); Cleveland Comments at 2 ("allow use in any environment").

2370-2390 MHz. The proposed rules expand the definition of health care facilities from that of the WMTS service to include hospitals, assisted living facilities, physician offices, ambulances and any other environments in which duly authorized health care professionals monitor, diagnose and treat patients.

Spectrum Sharing Requirements. While industry standardization efforts may occur in response to a spectrum allocation 19/, the proposed rules would not require the use any specific standard protocol. Rather, to promote general co-existence while still allowing flexibility, the proposed rules would simply require all devices to implement basic contention-based mechanisms to allow predictable and fair access to the spectrum. Specifically, devices would be required to employ some type of *unrestricted contention-based protocol,* as previously defined by the Commission. 20/ Examples of such contention-based protocols include listen-before-talk and frequency hopping. In addition to promoting coexistence of different manufactures' devices that employ dissimilar protocols, these mechanisms would also help to ensure non-interference to incumbent services regardless of incumbent protocol.

Proposed Frequency Bands. In its reply comments, GEHC identified several specific frequency bands that appeared to be suitable candidates for this allocation. 21/ After further investigation and study, including consultation with National Telecommunications and Information Administration ("NTIA") staff, GEHC has identified the 2360-2400 MHz band as the preferred option from among those candidates. Allocating this 40 MHz of spectrum *before sharing is taken into account* should provide a reasonable expectation of at least 20 MHz being

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19/ IEEE 802.15 has recently begun work on a standard for medical body area networks

20/ *See Wireless Operations in the 3650-3700 MHz Band*, Memorandum Opinion and Order, FCC 07-99, 22 FCC Rcd 10421 (rel. June 7, 2007) at ¶ 34.

21/ *See* GEHC Reply Comments at 7-11 (identifying the 410-450 MHz, 2300-2305 MHz, 2360-2400 MHz, and 2495-2496 MHz bands as potential candidates).

available for secondary use at health care facilities after avoiding frequencies in use by incumbent services. The 40 MHz frequency span is small enough to facilitate the use of simple, low cost electronic circuitry 22/ and yet is sufficient to provide meaningful frequency diversity useful for combating multipath fading and adjacent channel blocking problems.

GEHC proposes dividing this 40 MHz allocation into two channel sets: an inner set, consisting of 2370-2390 MHz, and an outer set, consisting of 2360-2370 MHz and 2390-2400 MHz. The outer channel set would be available for MBANS operations in any environment and would support modest MBANS usage densities in the presence of most incumbent operations. Inclusion of the inner set in the allocation would ensure that even the highest expected MBANS usage densities (*e.g.*, as may occur in hospitals) can be reliably supported even in the presence of significant incumbent operations. Use of the inner set would be limited to health care facilities, as described above, to protect radio astronomy operations in the band. 23/ In this manner, maximum MBANS deployment scenarios for GEHC's BSN application can be accommodated along with other MBANS applications.

The proposed bands are used principally for Amateur Radio and for Federal and non-Federal aeronautical telemetry and telecommand applications. A Federal allocation for Radiolocation (primary) and Fixed (secondary) was also added by the Commission in 2004 for the 2360-2390 MHz band, although there currently appear to be no such active operations in the band

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22/ GEHC has identified off-the-shelf integrated circuit transceivers that support these bands.

23/ The National Astronomy and Ionosphere Center ("NAIC") operates a 1-megawatt planetary radar from Arecibo, Puerto Rico. The radar uses a 20 MHz bandwidth centered at 2380 MHz. *See Reallocation of the 216-220 MHz, 1390-1395 MHz, 1427-1429 MHz, 1429-1432 MHz, 1432-1435 MHz, 1670-1675 MHz, and 2385-2390 MHz Government Transfer Bands,* Report and Order and Memorandum Opinion and Order, 17 FCC Rcd 368 (2002) at ¶ 68. GEHC is also proposing to prohibit airborne operations of MBANS devices, consistent with Commission precedent in protecting this band. *See id*.

except for certain experimental operations. 24/ As explained below, all of the incumbent operations in the outer channel set, being relatively high-power and long-range (“HPLR”) in nature, are well suited to coexist with low-power short-range ("LPSR”) frequency-agile MBANS devices. In the attached Appendix C, GEHC submits an Engineering Analysis that explains why the proposed MBANS devices would be able to successfully coexist with the HPLR systems found in the proposed outer channel set.

The 2390-2400 MHz band was formerly allocated to the asynchronous unlicensed PCS (“UPCS”) service, but the allocation was deleted due to lack of use by device manufactures. This band is generally considered undesirable for commercial services due to the need to share with amateur radio, the adjacent band Part 15 unlicensed and Part 18 ISM operations; the need to protect sensitive adjacent-band radio astronomy operations and the lack of a suitable band for frequency pairing. 25/ Motorola has previously commented that the 2395-2400 MHz band may only be of practical use for low-powered localized systems. 26/ This 2390-2400 MHz band contains a primary Amateur Radio allocation and is designated for fast-scan TV, high-rate data, packet, and control and auxiliary link transmissions, according to the Amateur Radio Relay League (“ARRL”) band plan. 27/ It is not used for weak signal operations. Expert representatives in the amateur community have previously commented that such point-to-point relay systems have good potential for sharing with commercial and even unlicensed services. For example, the

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24/ Northrop Grumman was issued an experimental license on June 12, 2006 for aeronautical mobile radiolocation related to Multi-Platform Radar Technology Insertion Program (MP-RTIP) using 2360-2390 MHz in the vicinity of Mojave, CA under the call sign WD2XXQ. The license is set to expire in May, 2008.

25/ NTIA, *Spectrum Reallocation Final Report*, NTIA Special Publication 95-32 (1995) (“*NTIA Final Report*”) at Section 2.

26/ *Id*. (citing comments from Motorola).

27/ ARRL, *FCC Rule Book*, 13th ed. (2004) at 4-26. This band is allocated to the amateur service in many countries, which would aid international harmonization.

Southern California Repeater and Remote Base Association ("SCRRBA") has stated to the Commission that "We can visualize how amateur fixed point-to-point services might effectively use the same spectrum as low power spread spectrum or medium bandwidth digital commercial devices intended for localized areas,"28/ and that amateur point-to-point relay systems are generally located on commercial communications sites which provide physical isolation that would facilitate potential sharing with Part 15 users 29/. MBANS devices would have similar (or likely less) transmit power and ubiquity as the unlicensed Part 15 devices contemplated in the context of those comments. In addition, ARRL has stated that wideband systems with low duty cycles and spread spectrum techniques are best suited to share the band with amateurs. 30/ MBANS devices satisfy this description. Notably, ARRL favorably cited the former UPCS as "a compatible arrangement… negotiated to permit the use of the 2390-2400 MHz band by both Amateur Radio Service and Part 15 Asynchronous UPCS." 31/ The UPCS rules incorporated a listen-before-talk ("LBT") mechanism that was analogous to the unrestricted contention-based protocol requirement proposed by GEHC for MBANS. Also, in comparison to UPCS devices, MBANS devices would operate over shorter distances, use significantly lower power and would be no more ubiquitous than UPCS devices were envisioned to become when ARRL commented favorably on that the UPCS allocation.

Federal and non-Federal aeronautical telemetry and telecommand operates on a primary basis in the 2360-2395 MHz portion of the proposed allocation. In a 2004 order, the

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28/ SCRRBA Comments, filed in ET Docket No. 94-32 (June 14, 1994) at 11 (attached to comments filed Dec. 17, 1994).

29/ SCRRBA Reply Comments, filed in ET Docket No. 94-32 (June 29, 1994) at 9 (attached to comments filed Dec. 17, 1994).

30/ *NTIA Final Report* at Section 2.

31/ Comments of ARRL, filed in RM-10166 (Aug 1, 2001), at note 7 (opposition to petition for rulemaking filed by AeroAstro).

Commission described the characteristics of the aeronautical mobile operations and determined that such operations could share the 2390-2395 MHz band with the amateur usage (primarily fast-scan amateur TV). 32/ Specifically, the Commission explained that:

> Aeronautical mobile use of the band will likely be predominantly at remote facilities… We observe that the potential for interference from amateur operations, even directional point-to-point operations, to flight testing operations, would be small, due to the high altitudes of aeronautical mobile flight testing transmitters, and the correspondingly high elevation and off-axis attenuation of high gain flight testing receive antennas on the ground. Although … we cannot rule out the possibility of interference to flight testing from amateur operations, we believe the likelihood of such an occurrence is limited by the remoteness of flight testing facilities… 33/

For similar reasons, the Commission reasoned that aeronautical mobile operations would not cause interference to amateur receivers due to large separation distances. The Commission observed "that aeronautical mobile operations will not be widespread and will often occur in the vicinity of test ranges. Thus, it is expected that there normally would be large separation distances between aeronautical mobile transmitters" and victim receivers.34/ For all these same reasons, MBANS devices should be able to share the band with aeronautical operations, especially given their much lower power and shorter range compared to amateur applications. Moreover, as explained in the Appendix C Engineering Analysis, MBANS devices should not cause interference to HPLR amateur operations.

Emissions limits. GEHC proposes that MBANS devices be permitted to have fundamental emissions of up to 0 dBm EIRP for the proposed maximum 1 MHz emission bandwidth, with proportionally less EIRP for narrower emissions bandwidths. In the attached Appendix B, GEHC submits propagation measurements and an Engineering Analysis that show

32/ *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services*, Seventh Report and Order, FCC 04-246, 19 FCC Rcd 21350 (rel. Oct. 21, 2004).

33/ *Id*. at ¶ 47.

34/ *Id*. at ¶ 48.

why this level of radiated power is required to ensure reliable communications for MBANS devices at the proposed operating frequency in the immediate vicinity of the patient. In the attached Appendix C, GEHC submits an Engineering Analysis showing that this limit is sufficient to ensure that MBANS devices will not cause harmful interference to incumbents in the proposed bands.

CONCLUSION

GEHC urges the Commission to move expeditiously by preparing a Further Notice which, consistent with the record in this proceeding, proposes the new spectrum allocation and rule changes necessary to make the next generation of wireless medical devices a reality. Any Further Notice issued by the Commission regarding the new allocation should seek comment on the technical rules proposed by GEHC for the band.

Respectfully submitted,

/s/ Ari Q. Fitzgerald

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December 27, 2007

APPENDIX A

Proposed Rules for the Medical Body Area Network Service

1. Section 1.1307 is amended by revising paragraph (b)(2) to read as follows:

§ 1.1307 Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.

* * * * *

(b) * * * * *

(2) Mobile and portable transmitting devices that operate in the Cellular Radiotelephone Service, the Personal Communications Services (PCS), the Satellite Communications Services, the Wireless Communications Service, the Maritime Services (ship earth stations only), the Specialized Mobile Radio Service, and the 3650 MHz Wireless Broadband Service authorized under Parts 22, 24, 25, 27, 80, and 90 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use, as specified in §§ 2.1091 and 2.1093 of this chapter. Unlicensed PCS, unlicensed NII and millimeter wave devices are also subject to routine environmental evaluation for RF exposure prior to equipment authorization or use, as specified in §§ 15.253(f), 15.255(g), 15.319(i), and 15.407(f) of this chapter. Portable transmitting equipment for use in the Wireless Medical Telemetry Service (WMTS) is subject to routine environment evaluation as specified in §§ 2.1093 and 5.1125 of this chapter. Equipment authorized for use in the Medical Implant Communications Service (MICS) as a medical implant transmitter (as defined in Appendix 1 to Subpart E of Part 95 of this chapter) or equipment authorized for use in the Medical Body Area Network Service (MBANS) as a MBANS transmitter is subject to routine environmental evaluation for RF exposure prior to equipment authorization, as specified in § 2.1093 of this chapter by finite difference time domain computational modeling or laboratory measurement techniques. Where a showing is based on computational modeling, the Commission retains the discretion to request that specific absorption rate measurement data be submitted. All other mobile, portable, and unlicensed transmitting devices are categorically excluded from routine environmental evaluation for RF exposure under §§ 2.1091, 2.1093 of this chapter except as specified in paragraphs (c) and (d) of this section.

2. Section 2.1093 is amended by revising paragraph (c) to read as follows:

§ 2.1093 Radiofrequency radiation exposure evaluation: portable devices.

* * * * *

(c) Portable devices that operate in the Cellular Radiotelephone Service, the Personal Communications Service (PCS), the Satellite Communications Services, the General Wireless Communications Service, the Wireless Communications Service, the Maritime Services, the Specialized Mobile Radio Service, the 4.9 GHz Band Service, the Wireless Medical Telemetry Service (WMTS), the Medical Implant Communications Service (MICS), and the Medical Body Area Network Service (MBANS), authorized under subpart H of part 22 of this chapter, parts 24, 25, 26, 27, 80 and 90 of this chapter, subparts H, I and M of part 95 of this chapter, and unlicensed personal communication service, unlicensed NII devices and millimeter wave devices authorized under subparts D and E, §§ 15.253, 15.255 and 15.257 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use. * * * * *

3. The Table of Frequency Allocations in Section 2.106 is amended by revising the entries for 2360-2390, 2390-2395 and 2395-2400 MHz, and adding footnote NG186 to read as follows:

International Table	United States Table		FCC Rule Part(s)
*****	Federal Table (MHz)	Non-Federal Table (MHz)	
*****	2360-2390 MOBILE US276 RADIOLOCATION G2 G120 Fixed	2360-2390 MOBILE US276 **NG186**	Aviation (87) **Personal (95)**
*****	2390-2395 MOBILE US276	2390-2395 MOBILE US276 AMATEUR **NG186**	Aviation (87) Amateur (97) **Personal (95)**
*****	2395-2400 G122	2395-2400 AMATEUR **NG186**	Amateur (97) **Personal (95)**

* * * * *

NON-FEDERAL GOVERNMENT (NG) FOOTNOTES

* * * * *

NG186 The 2360-2400 MHz band is allocated on a secondary basis for non-Federal mobile use (except aeronautical mobile uses are prohibited in 2370-2390 MHz) and is limited to Medical Body Area Network Service (MBANS) operations. MBANS stations are authorized by rule on the condition that they do not cause harmful interference to, and must accept interference from, stations authorized to operate on a primary basis in the 2360-2400 MHz bands.

4. Section 95.401 is amended by adding paragraph (h) to read as follows:

§ 95.401 (CB Rule 1) What are the Citizens Band Radio Services?

* * * * *

(h) Medical Body Area Network Service (MBANS) – a wideband, low power radio service used for the transmission of non-voice data to and from medical devices for the purposes of monitoring, diagnosing or treating patients by duly authorized health care professionals. The rules for this service are contained in subpart M of this part.

5. Section 95.601 is amended by revising the last sentence in the text to read as follows:

§ 95.601 Basis and purpose.

* * * * *

The Personal Radio Services are the GMRS (General Mobile Radio Service)—subpart A, the Family Radio Service (FRS)—subpart B, the R/C Radio Control Radio Service)—subpart C, the CB (Citizens Band Radio Service)—subpart D, the Low Power Radio Service (LPRS)—subpart G, the Wireless Medical Telemetry Service (WMTS)—subpart H, the Medical Implants Communication Service (MICS)—subpart I, the Multi-Use Radio Service (MURS)—subpart J, Dedicated Short-Range Communications Service On-Board Units (DSRCS-OBUs)—subpart L, and Medical Body Area Network Service (MBANS)—subpart M.

6. Section 95.603 is amended by adding paragraph (i) to read as follows:

§ 95.603 Certification required.

* * * * *

(i) Each MBANS transmitter must be certificated, except for MBANS transmitters that are not marketed for use in the United States, but which otherwise comply with the MBANS technical requirements and are operated in the United States by individuals who have traveled to the United States from abroad. MBANS transmitters are subject to the radiofrequency radiation exposure requirements specified in Sections 1.1307 and 2.1093 of this chapter, as appropriate. Applications for equipment authorization of devices operating under this section must contain a finite difference time domain (FDTD) computational modeling report showing compliance with these provisions for fundamental emissions. The Commission retains the discretion to request the submission of specific absorption rate measurement data.

7. Section 95.605 is amended by revising the text to read as follows: Any entity may request certification for its transmitter when the transmitter is used in the GMRS, FRS, R/C, CB, IVDS, LPRS, MURS, MICS, or MBANS following the procedures in part 2 of this chapter.

* * * * *

8. Section 95.626 is added to read as follows:

§ 95.626 MBANS Transmitter Frequencies

Stations may operate on any of the frequencies in the 2360-2400 MHz band, subject to the authorized locations in accordance with § 95.1603 and provided that the out-of-band emissions are attenuated in accordance with § 95.635.

9. Section 95.631 is amended by adding paragraph (l) to read as follows:

§ 95.631 Emission types.

* * * * *

(l) An MBANS station may transmit any emission type appropriate for communications in this service. Voice communications, however, are prohibited.

10. Section 95.633 is amended by adding paragraph (h) to read as follows:

§ 95.633 Emission bandwidth.

* * * * *

(h) For transmitters in the MBANS:

(1) The maximum authorized emission bandwidth is 1MHz.

(2) Lesser authorized emission bandwidths may be employed, provided that the unwanted emissions are attenuated as provided in § 95.635 and the transmitter power complies with the limits specified in § 95.639(j).

(3) Emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 20 dB down relative to the maximum level of the modulated carrier. Compliance with the emission bandwidth limit is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

11. Section 95.635 is amended by revising paragraph (b) and adding paragraph (e) to read as follows:

§ 95.635 Unwanted radiation.

* * * * *

(b) The power of each unwanted emission shall be less than TP as specified in the applicable paragraphs listed in the following table:

Transmitter	Emission type	Applicable paragraphs (b)
*****	*****	*****
MBANS ……………………	As specified in paragraph (g)	
*****	*****	*****

* * * * *

(g) For transmitters designed to operate in the MBANS, emissions shall be attenuated in accordance with the following:

(1) Emissions more than 500 kHz outside of the MBANS band (2360-2400 MHz) shall be attenuated to a level no greater than the following field strength limits:

Frequency (MHz)	Field strength (µV/m)	Measurement distance (m)
30-88 ………………………..	100	3
88-216 ………………………	150	3
216-960 …………………….	200	3
960 and above ………………	500	3
Note – At band edges, the tighter limit applies.		

(2) The emission limits shown in the above table are based on measurements employing an average detector using a minimum resolution bandwidth of 1 MHz.

(3) The emissions from an MBANS transmitter must be measured to at least the second harmonic of the highest fundamental frequency designed to be emitted by the transmitter.

(4) Emissions within the MBANS band (2360-2400 MHz) more than 500 kHz away from the center frequency of the spectrum the transmission is intended to occupy, will be attenuated below the transmitter output power by at least 20 dB. Compliance with this limit is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

12. Section 95.639 is amended by adding paragraph (j) to read as follows:

§ 95.639 Maximum transmitter power.

* * * * *

(j) In the MBANS the following limits apply:

(1) For MBANS transmitters, the maximum EIRP over the frequency bands of operation shall not exceed the lesser of 1 mW or 10 log B dBm, where B is the 20 dB emission bandwidth in MHz.

(2) The antenna associated with any MBANS transmitter must be supplied with the transmitter and shall be considered part of the transmitter subject to equipment authorization. Compliance is based on measurements using a peak detector function and measured at its maximum power level.

(3) The maximum EIRP may be determined by measuring the radiated field from the equipment under test at 3 meters using a calibrated antenna and calculating the radiated power. Alternative techniques acceptable to the Commission may be used. Measurements are made over a bandwidth of 1 MHz or the 20 dB emission bandwidth of the device, whichever is less. A resolution bandwidth less than the measurement bandwidth can be used, provided that the

measured power is integrated to show total power over the measurement bandwidth. If the resolution bandwidth is approximately equal to the measurement bandwidth, and much less than the emission bandwidth of the equipment under test, the measured results shall be corrected to account for any difference between the resolution bandwidth of the test instrument and its actual noise bandwidth.

13. Section 95.649 is amended by revising the text to read as follows:

§ 95.649 Power capability.

No CB, R/C, LPRS, FRS, MICS, MURS, WMTS, or MBANS unit shall incorporate provisions for increasing its transmitter power to any level in excess of the limits specified in § 95.639.

14. Appendix 1 to Subpart E of Part 95—Glossary of Terms is revised to read as follows:
The definitions used in part 95, Subpart E are:

* * * *

Contention-based protocol. A protocol that allows multiple users to share the same spectrum by defining the events that must occur when two or more transmitters attempt to simultaneously access the same channel and establishing rules by which a transmitter provides reasonable opportunities for other transmitters to operate. Such a protocol may consist of procedures for initiating new transmissions, procedures for determining the state of the channel (available or unavailable), and procedures for managing retransmissions in the event of a busy channel.

MBANS. Medical Body Area Network Service.

MBANS master transmitter. A MBANS transmitter responsible for frequency agility / dynamic frequency selection ("DFS") functions within an MBANS network.

MBANS slave transmitter. A MBANS transmitter within an MBANS network for which the transmit frequency is determined by an associated MBANS master.

MBANS transmitter. A transmitter authorized to operate in the *MBANS*.

Restricted contention-based protocol. A contention-based protocol that can avoid co-frequency interference with other devices using the same contention-based protocol.

Unrestricted contention-based protocol. A contention-based protocol that can avoid co-frequency interference with other devices irrespective of protocol.

* * * * *

15. Subpart M is added to read as follows:

Subpart M—Medical Body Area Network Service (MBANS)

§ 95.1601 Eligibility

Operation in the MBANS is permitted by rule and without an individual license issued by the FCC. Duly authorized health care professionals are permitted by rule to operate MBANS transmitters. In addition, any person is authorized to operate MBANS transmitters if prescribed by a duly authorized health care professional. Manufacturers of MBANS transmitters and their representatives are authorized to operate MBANS transmitters for the purpose of developing, testing and demonstrating such equipment. The term "duly authorized health care professional" means a physician or other individual authorized under state or federal law to provide health care services using prescription medical devices. Operations that comply with the requirements of this part may be conducted under manual or automatic control and on a continuous basis.

§ 95.1603 Authorized locations.

(a) MBANS operation using frequencies of the outer MBANS channel set defined by § 95.1611 is authorized anywhere CB station operation is authorized under § 95.405.

(b) MBANS operation using frequencies of the inner MBANS channel set defined by § 95.1611 is authorized anywhere within a health care facility provided the facility is located anywhere a CB station operation is permitted under § 95.405. For purposes of this section, the definition of a health care facility includes hospitals, nursing homes, assisted living facilities, physician offices and other environments in which duly authorized health care professionals monitor, diagnose and treat patients. This authority extends to mobile vehicles including ambulances.

§ 95.1605 Station Identification.

An MBANS station is not required to transmit a station identification announcement.

§ 95.1607 Station inspection.

All MBANS apparatus must be made available for inspection upon request by an authorized FCC representative.

§ 95.1609 Permissible communications.

(a) MBANS transmitters may transmit data signals as permitted in this subpart. Voice communications are prohibited.

(b) Except for the purposes of development, testing and demonstration per § 95.1601, MBANS transmitters may transmit only information used for monitoring, diagnosing or treatment of patients by duly authorized health care professionals.

(c) MBANS transmitters may be interconnected with other telecommunications systems including the public switched telephone network.

§ 95.1611 Channel use policy.

(a) The channels authorized for MBANS operation by this part of the FCC Rules are available on a shared basis only and will not be assigned for the exclusive use of any entity.

(b) Operation is subject to the condition that MBANS transmitters do not cause harmful interference to, and must accept interference from, stations authorized to operate on a primary basis in the 2360-2400 MHz bands.

(c) All MBANS stations must employ an unrestricted contention-based protocol.

(d) MBANS stations operate using frequencies selected from inner and outer channel sets. The outer channel set is defined as the combination of 2360-2370 and 2390-2400 MHz, inclusive. The inner channel set is defined as 2370-2390 MHz. Use of the inner and outer channel sets by MBANS stations is limited by § 95.1603.

§ 95.1613 Antennas.

No antenna for an MBANS transmitter shall be configured for permanent outdoor use.

§ 95.1617 Labeling requirements.

(a) MBANS master transmitters shall be labeled as provided in Part 2 of this chapter and shall bear the following statement in a conspicuous location on the device: "This device may not interfere with stations authorized to operate on a primary basis in the 2360-2400 MHz bands, and must accept any interference received, including interference that may cause undesired operation."

(b) Where an MBANS master transmitter is constructed in two or more sections connected by wire and marketed together, the statement specified in this section is required to be affixed only to one section.

(c) The statement specified in this section, the FCC ID number associated with the transmitter and the information required by Section 2.925 of the FCC Rules may be placed in the instruction manual for the transmitter in lieu of being placed directly on the transmitter.

§ 95.1219 Marketing limitations.

Transmitters intended for operation in the MBANS may be marketed and sold only for those uses described in § 95.1609 of this part.

APPENDIX B

Engineering Analysis of On-Body Link Design Considering Body-Centric Propagation and Required Bandwidth

I. INTRODUCTION

GE Healthcare proposes rules for the creation of a Medical Body Area Network Service (MBANS) allowing operation of body sensor network (BSN) devices on a secondary basis within the 2360 to 2400 MHz band. This study summarizes radio propagation for body-worn devices and presents a representative link budget for MBANS devices to support the proposed, maximum radiated power level of 0 dBm. This study also provides support for the request for a 40 MHz shared spectrum allocation by addressing bandwidth requirements for a single MBANS network as well as collocated networks.

II. BODY-CENTRIC RADIO PROPAGATION

A. Radio Propagation For Body-Worn Antennas

There has been considerable, recent effort devoted to characterize and quantify the radio propagation channel for body-worn devices. This effort has focused on propagation in the 2400 to 2483 MHz unlicensed band as well as the 2 to 6 GHz band used by ultra-wideband (UWB) applications. The proximity of the 2.4 GHz unlicensed band to GE Healthcare's proposed 2360 to 2400 MHz band permits the use of these previous efforts in this analysis.

Simulations and measurements have been used to characterize the propagation of radio waves about the body as creeping waves which exhibit exponential decay of power. 1/ Path gain measurements have been performed in anechoic chambers and laboratory environments to quantify the influence of body posture, body movement, and antenna position. Measurements performed with monopole antennas oriented perpendicular to the body surface and placed on the chest and trunk showed average path gain values of –41 and –44 dB for anechoic chamber and laboratory environments, respectively. For perpendicular monopoles located on the chest and opposite wrist, average path gain of –55.5 and –57 dB was measured in the anechoic chamber and laboratory, respectively. 2/ Path gain measurements approximated a lognormal distribution and ranged 24 to 38 dB about the average values in the laboratory given body posture changes, including walking, bending and turning. 3/

1/ *Antennas and Propagation for Body-Centric Wireless Communications*, Peter S. Hall and Yang Hao, editors, Artech House, Norwood, MA, 2006. Chapter 3, page 48.

2/ "Antennas and Propagation for On-Body Communication Systems", P. Hall, et. al., *IEEE Antennas and Propagation Magazine*, Volume 49, Number 3, June 2007, pages 41-58.

3/ *Ibid*., page 44.

The simulation and measurements performed by others at 2.4 GHz have relied upon monopole antennas with a ground plane oriented perpendicular to the body surface. Such an antenna is not well-suited to small, disposable, body-worn medical devices. As a result, GE Healthcare worked with Queen Mary University in London to simulate the performance of various printed circuit board antennas placed in close proximity to the skin. 4/ Various printed antenna types were considered, including dipole, monopole, loop and inverted-L antennas. These simulations showed antenna efficiency on the order of 35 to 50% for inverted-L antennas located on the chest or wrist. Simulations also estimated path gain of -51 and -55 dB between printed monopole antennas on the left waist and right chest or right thigh, respectively. GE Global Research measured the path gain between printed monopole and inverted-L antennas in the laboratory environment with a similar set of body posture and movements used by other researchers. 5/ GE measurements of path gain, S21, using printed, inverted L antennas placed 10 mm from the skin are summarized in Table 1. These measurements were made with an Agilent E5071 network analyzer sweeping over 2.4 to 2.525 GHz range using a 1 MHz resolution bandwidth. Table 1 shows just the 1 MHz channel at 2.4 GHz. Figure 1 illustrates the measured path gain for subject 1 given various body postures and movements. Visual inspection of the measured path gain supports modeling using lognormal or Weibull distributions.

Comparison of GE measurements with those from other research groups reveals similar variation in path gain given human subject movements. However, GE's measurements using printed, planar antennas show larger attenuation between the body-worn antennas than reported by others using quarter wavelength monopole antennas oriented perpendicular to the skin surface. This attenuation, characteristic of the printed antennas, was also reported by the University of Birmingham, where average path gains of –44.4 and –56.3 dB were measured for quarter wave monopole and planar inverted antenna, respectively. 6/

Table 1 – Measured path gain at 2.4 GHz using inverted-L antenna placed 10 mm from skin

Body Path	Path Gain Average (dB)	Path Gain Standard Deviation (dB)	Path Gain Range (dB)
Left Waist to Right Chest Subject 1	-57.7	5.0	35.7
Subject 2	-60.5	6.8	60.2

4/ "Parametric Study of Wearable Antennas with Varying Distances from the Body and Different On-Body Postions", A. Alomainy, Y. Hao, D. Davenport, *Antennas and Propagation for Body-Centric Wireless Communications,* 2007 IET Seminar on _____, vol.___, no.___, pp.84-89, 24-24, April 2007.

5/ *Antennas and Propagation for Body-Centric Wireless Communications*, Peter S. Hall and Yang Hao, editors, Artech House, Norwood, MA, 2006. Chapter 3, page 43.

6/ "Antennas and Propagation for Body Centric Communications", P. S. Hall, *Antennas and Propagation for Body-Centric Wireless Communications*, 2007 IET Seminar on ___, vol.___, no.___, pp.1-4, 24-24, April 2007.

Left Waist to Right Wrist Subject 1	-68.8	6.5	56.0
Subject 2	-63.9	5.6	58.8

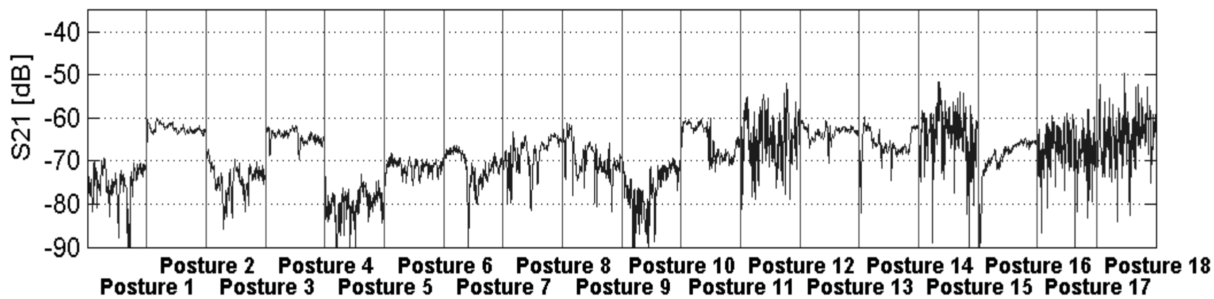

Figure 1 – Path gain measurements for 1 MHz channel at 2.4 GHz using inverted-L antenna placed 10 mm from skin. Multiple body postures considered: standing upright, standing turned left, standing turned right, standing leaning forward, standing head forward, standing head right, standing arms out to side, standing arms over head, standing forearms forward, standing moving freely, sitting arms hanging down, sitting hands in lap, sitting moving freely, standing upright, walking back and forth, walking back and forth moving freely.

B. Radio Coupling Between Bodies

The off-body propagation of radio signals from nearby BSNs represents a source of interference for an individual body sensor network. Considerably less work has been reported about the coupling of radio signals between body-worn antennas on different, collocated people. Measurements made by University of Birmingham used quarter wave monopole antennas oriented perpendicular to the skin to measure the interference between two BSNs at 2.45 GHz. Path gain between antennas at the left waist of one person and the near, right side of a second person was measured. Average path gain at 1.5 meter separation ranged between –47.1 dB and –51.1 dB, while standard deviation ranged between 4.5 and 7.5 dB. 7/

GE Global Research measured the coupling between patients over the 2400 to 2500 MHz band using an Agilent PNA N5230A network analyzer. Inverted-L antennas were place on two subjects. Path gain, S21, measurements were made at 1 MHz sampling and with a variety of antenna locations, antenna separations, and other bodies in the room. An average path loss of –67.9 dB and standard deviation of 5 dB was observed between the antennas. This average was calculated over the entire frequency range. The larger attenuations observed by GE testing can again be attributed to the use of printed, planar antennas rather than quarter wave monopole structures perpendicular to the skin.

7/ *Ibid*., page 2.

III. MBANS RADIATED POWER REQUIREMENTS

A. Performance Objective

In order to be universally applicable through all levels of acuity, BSNs must be capable of reliably conveying unprocessed life-critical monitoring data to devices that are responsible for processing and primary alarming. In these scenarios, if the link were lost, a serious event such as arrhythmia or hypoxia could go unalarmed. Therefore wireless quality of service ("QOS") will be a critical consideration for BSN design. BSNs must be able to provide reliable communications on and in the immediate vicinity of the patient's body.

Limiting packet error rate on the BSN wireless link to be no more than 10% provides a reasonable design objective for BSN system performance. Assuming data packets contain 256 bits and independent bit errors, the 10% packet error requirement can be translated into a maximum, tolerable bit error rate of $4x10^{-4}$.

A review of commercially available transceivers for the unlicensed 2.4 GHz band affords insight as to the sensitivity likely achievable by an MBANS receiver and minimum received signal level required to attain the bit error rate limit of $4x10^{-4}$. The Nordic nRF24L01 transceiver uses GFSK modulation and operates at 1 Mbps data rate with $1x10^{-3}$ bit error rate given –85 dBm signal level. 8/ The Texas Instruments Chipcon CC2510 transceiver uses MSK modulation to operate at 500 kbps data rate with an effective bit error rate of $6.25x10^{-6}$ given –82 dBm signal level. 9/

The probability of bit error, P_{BER}, for noncoherently demodulated FSK and coherently demodulated FSK modulation can be expressed as 0.5*exp(-0.5*Eb/No) and Q{sqrt(Eb/No)}, respectively. 10/ Recall that the Q{z} can be related to the complementary error function, erfc, as 0.5*erfc(z/sqrt(2)). Figure 2 graphs this equation for bit error probability along with the $4x10^{-4}$ upper specification limit. These graphs can be used to estimate the minimum signal level at which the $4x10^{-4}$ specification limit will be satisfied. For both demodulation types, an increase of 1 dB in Eb/No, or equivalent, carrier to noise ratio, will move the performance of the receiver BER from $1x10^{-3}$ to below our desired $4x10^{-4}$. This 1 dB implies that a signal level of –84 dBm will yield sufficient performance with the Nordic nRF24L01 transceiver operating at 1 Mbps data rate. This signal level is comparable with the Chipcon CC2510, which operates with sufficiently low BER at 500 kbps.

Based on these estimates, a minimum signal level of –84 dBm will be considered in the following section's link budget analysis.

8/ *NRF24L01 Single Chip Transceiver Product Specification*, Nordic Semiconductor, July 2007. Via the Internet at www.nordicsemi.com. Accessed December 6, 2007.

9/ *CC2510Fx / CC2511Fx Low-Power SoC (System-on-Chip) with MCU, Memory,2.4 GHz RF Transceiver, and USB Controller*, Texas Instruments, Document SWRS055D, 2007. Via the Internet at www.ti.com. Accessed December 6, 2007.

10/ *Wireless Communications Principles & Practice*, T. Rappaport, Prentice-Hall PTR, 1996.

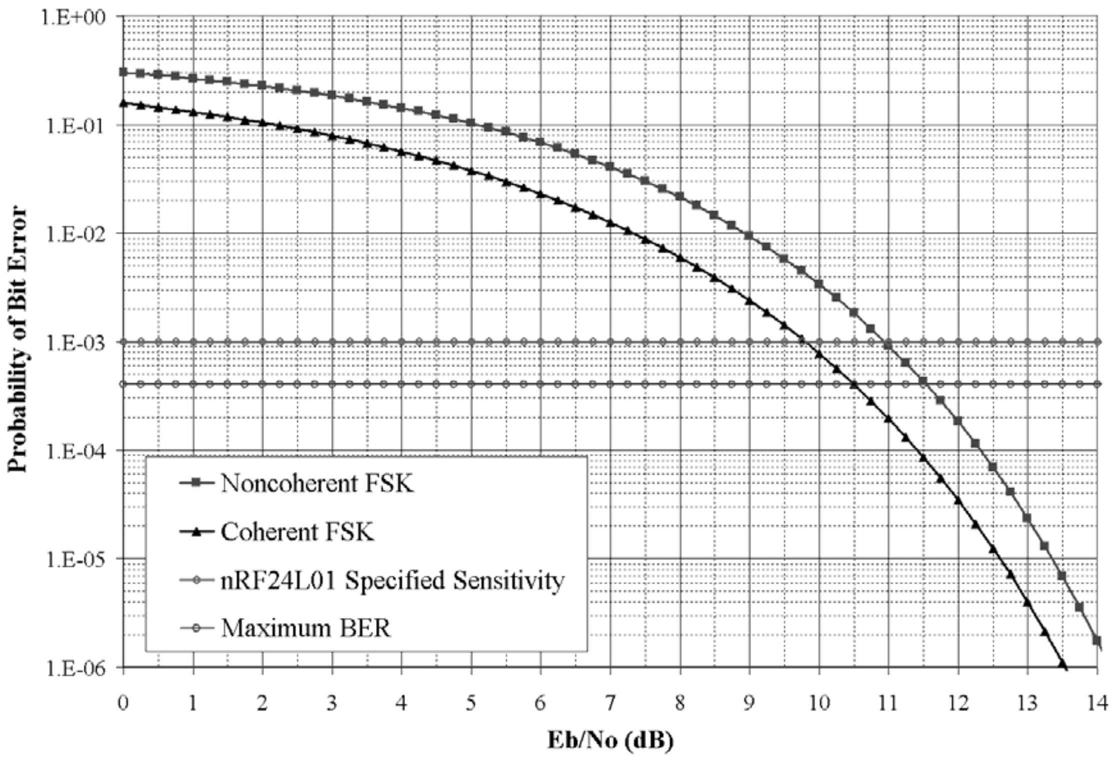

Figure 2 – Bit Error Probability for Coherent FSK

B. Link Analysis

The path loss measurements presented above support the estimation of path loss as a normal random variable with average value –63 dB and a standard deviation of 6 dB. For a normal random variable, 99.98% of the distribution falls above a threshold set 3.5 times the standard deviation below the average value. For the on-body propagation channel 99.98% of the path gain will occur at values above –63 – (3.5*6) = -84.0 dB.

GE Healthcare has proposed a maximum EIRP limit of 0 dBm. Given a 0 dBm transmission, the on-body propagation channel model predicts received signal level exceeding –84 dBm greater than 99.98% of the time. The proposed 0 dBm EIRP limit affords a robust wireless link that satisfies the –84 dBm, minimum signal level requirement. Temporal and frequency diversity technique might be applied to provide additional margin relative to the minimum signal level.

IV. MBANS BANDWIDTH REQUIREMENTS

A. Receiver Characteristics

GE Healthcare proposes maximum emission bandwidth of 1 MHz. Such a bandwidth permits transmission of data at 1 Mbps using GFSK or other modulation techniques instantiated in commercially available transceiver products. Operation at higher data rates (i.e., 500 kbps and 1

Mbps) enables transmission of temporally short data bursts and low-duty cycle operation. Low duty-cycle operation facilitates low power consumption and long battery life. Low duty-cycle operation also promotes coexistence among BSNs and other radio devices. Operation at 1 Mbps data rate over-the-air allows transfer of 32 byte data messages in approximately 256 usec. With such short data bursts, multiple packets can be exchanged, including acknowledgements and retransmissions, while maintaining a duty cycle on the order of 1% to 5%.

Commercially available receivers, such as the Nordic nRF24L01 and Texas Instruments CC2510, afford modest filtering capabilities. The Nordic nRF24L01 is specified for 21 dB of selectivity for equal, 1 Mbps modulation located 2 MHz away from the given channel. 11/. The Texas Instruments CC2510 is specified for 25 dB selectivity for equal, 500 kbps modulation located 2 MHz away from the given channel. 12/ Additional, band pass filtering is not practical given the potential need to change channels to avoid primary radio services or to realize frequency diversity for improved link quality.

The retransmission of short data packets on multiple frequency channels is an effective diversity technique that is readily implemented using commercially available transceiver chips. Transmitting on a second frequency allows the BSN system to combat any frequency specific attenuations resulting from the propagation environment or body posture. Coherence bandwidth is a measure representing the range of frequencies over which two frequency components have a strong potential for amplitude correlation. 13/ GE Global Research measurements of on-body and body-coupled propagation with body-worn, printed antennas reveal coherence bandwidths of approximately 6 to 10 MHz, respectively. These coherence bandwidths are derived with respect to a 0.9 threshold on the correlation function between path gain measurements of 1 MHz channels ranging between 2400 and 2500 MHz.

The desire for low duty-cycle operations using commercially available transceivers with frequency diversity and the need to coexist amongst each other and with primary, incumbent radio devices motivate GE Healthcare's request for an MBANS allocation spanning 2360 to 2400 MHz.

B. Collocation Analysis and Simulation

GE Healthcare envisions multiple, collocated BSNs within the hospital or other environments. Illustrative examples of BSN collocation can be drawn from patients gathered in an elevator lobby, eating in the cafeteria or visiting a lounge area. The body-coupled signal path, as detailed above, imposes path gain comparable to the on-body path. Equivalent signal levels combined with

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11/ *NRF24L01 Single Chip Transceiver Product Specification*, Nordic Semiconductor, July 2007. Via the Internet at www.nordicsemi.com. Accessed December 6, 2007.

12/ *CC2510Fx / CC2511Fx Low-Power SoC (System-on-Chip) with MCU, Memory,2.4 GHz RF Transceiver, and USB Controller*, Texas Instruments, Document SWRS055D, 2007. Via the Internet at www.ti.com. Accessed December 6, 2007.

13/ *Wireless Communications Principles & Practice*, T. Rappaport, Prentice-Hall PTR, 1996.

modest receiver selectivity characteristics results in a significant potential for interference between collocated BSNs.

If all BSNs within a spatial region were perfectly synchronized in time and frequency, it would be possible to share a single, 1 MHz channel among multiple patients. Assuming a 2% duty cycle for an individual BSN node and time division multiple access used within each BSN, a total of 50 BSN devices could be supported on a perfectly synchronized channel. However, such synchronization requires a distributed infrastructure or active management between BSN hubs on collocated patients. A distributed infrastructure imposes significant complexity and cost to a BSN deployment, as a downlink must be provisioned with reliable coverage for every BSN hub throughout the facility. Such a synchronization infrastructure represents a significant obstacle to commercialization of BSNs within a medical environment.

Realization of synchronization via exchange of messages between BSN hub devices on different patients is no less an obstacle given the need for robust message exchange and the additional receiver and processing requirements imposed on the BSN hub. These messages will consume bandwidth and battery life of the BSN hubs. Each BSN hub would increase its traffic in relation to the number of proximate BSN hubs to maintain synchronization. Additional messages would be required for discovering proximate BSNs. This additional traffic conveys no patient data and, therefore, is highly inefficient. Furthermore, there is no commercially proven protocol for synchronization of independent, mobile networks. The development of distributed BSN synchronization requires further research and is likely to consume much of the spectrum that it seeks to reuse.

Given the constraints noted above, an unsynchronized BSN solution represents the fastest path to market and delivery of benefit to the patient population. Unsynchronized BSNs can operate using contention-based protocols, such as listen-before-talk and/or frequency hopping, to facilitate coexistence amongst each other as well as primary radio systems. The body-coupled signal, as detailed above, imposes attenuation on the same order as the on-body channel, making listen-before-talk highly effective. Frequency hopping is another proven technique that supports the mobility of BSNs as patients move about with respect to one another.

The probability of interference among frequency hopping networks can be statistically estimated and bounded with a high level of confidence. An upper limit on the probability of collision between frequency hopping Bluetooth networks was determined by El-Hoiydi as: $1-\left[2(1-r)GP_o+(2r-1)(GP_o)^2\right]^{N-1}$. In this equation, G = 1 represents 100% traffic load on the Bluetooth network, r is the ratio between packet and slot duration, N is the number of interfering networks and P_o is a ratio (M-1)/M of the number of available frequency channels, M. 14/ This equation is evaluated in Figure 3 as a function of the number of interfering BSNs, N, as well as the number of 1 MHz wide channels available for hopping, M. Results of Figure 3 are calculated

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14/ "Interference between Bluetooth networks-upper bound on the packet error rate", A. El-Hoiydi, *Communications Letters, IEEE* , vol.5, no.6, pp.245-247, June 2001.

using G = 1 and r taken as the ratio of a 256 x 10^{-6} second packet duration and slot duration of 2 x 10^{-3} seconds.

A scenario with two patients sharing a room requires more than 4 frequency channels for hopping to satisfy the 10% packet error goal defined previously. A scenario with 10 patients in a lounge, elevator lobby, imaging suite waiting area or cafeteria requires at least 25 channels to meet the 10% packet error rate target.

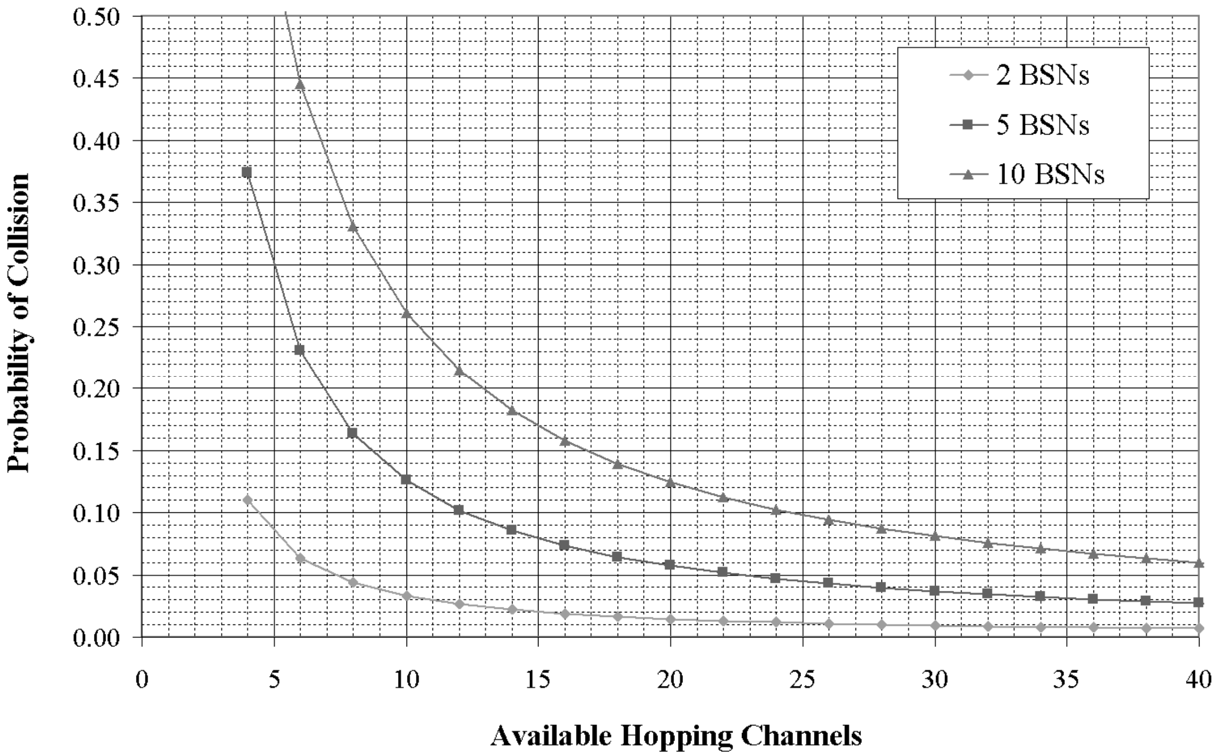

Figure 3 – Upper Bound on Packet Collision Probability for Bluetooth Networks

GE Global Research has simulated the scenario of patient BSNs moving within a 3-meter by 3-meter room. Each BSN implements a TDMA sensor network with a hub and one or more BSN sensors. During each TDMA frame, a single packet is transmitted by the hub and each sensor node on a single frequency. The frequency is used for all packets transmitted during that frame and changes every 5 frames in an uncoordinated and asynchronous manner. Average packet error rate values have been determined based on numerous runs of the simulation with stationary and mobile BSNs. Figure 4 shows the average packet error probability for 2 and 10 patient scenarios. In the two patient scenario, each BSN has a hub and two sensors. In the ten patient scenario, each BSN has 10 sensors and a hub. Each scenario was evaluated with the BSNs stationary and mobile. On-body and body-body propagation has been modeled along with receiver blocking characteristics. In this scenario, increasing the number of 1 MHz channels in the available hopping pool decreases the probability of sequential packet loss. When only two BSNs are in the same room, 5 MHz provides ample opportunity for frequency hopping and satisfaction of the 10%

packet error target. When ten, heavily loaded and mobile BSNs are in the same room, approximately 18 MHz is required to support the BSN population with acceptable packet error loss probability.

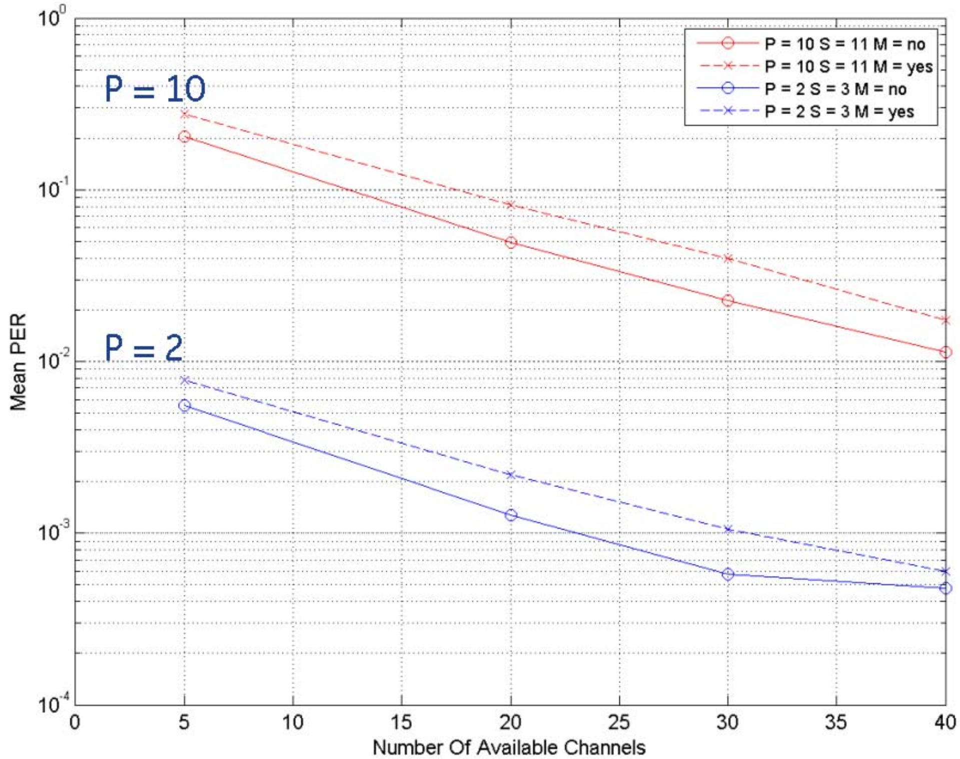

Figure 4 - Simulated BSN Collocation Average Packet Error Probability. In the legend P denotes the number of BSNs, S represents the number of sensors in each BSN and M indicates whether the BSNs were mobile or stationary.

GE Healthcare envisions a possible deployment scenario of 10 or more collocated BSNs each with multiple sensors. Furthermore, such a scenario may be found in an urban hospital, adjacent to an aeronautical test flight mission and/or proximate to active amateur radio, fast scan television users. In such a situation, a 40 MHz allocation would provide sufficient bandwidth for BSN devices utilizing contention based protocols to operate with sufficiently low packet error rate and without impact to primary radio service users.

GE Healthcare's request for MBANS operation within 2360 to 2400 MHz represents a 40 MHz band allocation sufficient for sharing with primary users and collocated BSNs. This request is based upon the need to support frequency diversity within a BSN, unsynchronized collocation of BSNs and spectrum to share with primary amateur and aeronautical radio systems.

APPENDIX C

Coexistence Engineering Analysis

I. INTRODUCTION

GE Healthcare proposes rules for the creation of a Medical Body Area Network Service (MBANS) allowing operation of body sensor network (BSN) devices on a secondary basis within the 2360 to 2400 MHz band. The proposed frequency band is used principally for Amateur Radio and for Federal and non-Federal aeronautical telemetry applications. Although a Federal allocation for Radiolocation (primary) and Fixed (secondary) was also added by the Commission in 2004, there currently appear to be no such active operations in the band except on an experimental basis. These incumbent operations can be classified as high power, long range and, as such, are well suited to coexist with low power, short-range MBANS devices. This study investigates the potential for harmful interference from MBANS devices to other authorized radio services in the 2360-2400 MHz band and concludes that MBANS devices can operate in the band with very low probability of causing harmful interference to other authorized services.

II. BACKGROUND

A. Technical Characteristics of MBANS Systems

A body sensor network includes multiple, body-worn MBANS transmitters, each capable of radiating equal power levels limited to 0 dBm per the GE Healthcare proposal. BSN sensor nodes transmit their sensor data to the BSN hub. The BSN hub transmits control information, (*e.g.*, frequency channel, time synchronization, etc.) and acknowledgements to the sensor nodes. Proposed channel bandwidths of 1 MHz support data transfer using low-cost transceivers and GFSK modulation up to 1 Mbps. A sequential transfer of data from slave devices is assumed. Such sequential sensor exchange could be accomplished using time division or carrier sense multiple access techniques. As a result, the duty cycle of a single BSN transmitter is assumed to be low, on the order of 1 to 5%. The aggregate duty cycle, considering multiple BSN devices on a single patient, is assumed to be less than 25%.

The parameters used for the analysis of MBANS links are those of a classic interference link budget using minimum coupling loss between transmitter and victim receiver. Parameters considered include maximum radiated power, carrier frequency, distance to the victim receiver, free space loss, duty cycle, receiver bandwidth and thermal noise floor of the victim receiver. This analysis assumes co-channel interference between the MBANS transmitter and the victim radio whose tuning range permits overlap with one or more MBANS channels.

B. Technical Characteristics of Amateur Radio Receivers

Amateur radio licensees are authorized to use all modes of radio communication within the 2390-2400 MHz band. Table 1 lists the band plan for this frequency range defined by the National Association for Amateur Radio (ARRL), effective February 2007.

Table 1 – ARRL Band Plan Effective February 23, 2007

Frequency Range (MHz)	Radio Mode
2390.0 – 2396.0	Fast-scan TV
2396.0 – 2399.0	High-rate data
2399.0 – 2399.5	Packet
2399.5 – 2400.0	Control and auxiliary links

Fast-scan TV and high-rate data modes are similar in their use of at least a 3 MHz bandwidth and high-gain, directional antennas for robust link performance. Packet and control/auxiliary link modes are similar in their narrow bandwidth and low data rate characteristics. Based on these similarities, the MBANS interference analysis considers two categories of radio receiver characteristics for amateur radio. Table 2 summarizes these categories and the assumed receiver parameters for each. Antenna gain values are conservatively assumed, considering elevation pattern of directional, possibly roof-top antennas, for category 1 and omnidirectional antennas for category 2. The noise figure parameter is conservatively chosen to reflect minimum values of consumer, digital television systems or amateur systems using frequency translation stages with VHF or UHF receivers.

C. Technical Characteristics of Aeronautical Telemetry Receivers

The U.S. Table of Frequency Allocations limits the primary Mobile service allocation in the 2360 to 2395 MHz band to aeronautical telemetry applications. Information on aeronautical telemetry radio systems was derived from telemetry standards published by the Range Commanders Council (RCC). 1/ The RCC telemetry standard defines multiple modulation types and bit rates. The bit rate for FQPSK-B, FQPSK-JR and SOQPSK-TG modulations range between 1 and 20 Mbps. The RCC telemetry standard also defines a range of intermediate frequency bandwidths. Aeronautical telemetry systems employ highly directional and steered antennas at the ground station to reliably receive the data signal from the airborne platform. The RCC telemetry application handbook states that typical values for receive antenna gain to system noise temperature (G/T) for a modern, 7 meter dish at 2.25 GHz is 18 to 20 dB/degree Kelvin. 2/ Recommendations of the International Telecommunication Union's Radiocommunication Sector, ITU-R, include a sidelobe composite pattern for 2.44 and 10 meter receive antennas at 1452-1525 MHz. 3/ Such a large dish antenna will have significant directivity pointed up towards the aircraft. Assuming a –3 dB beamwidth of

1/ Telemetry Standards (Part 1), Document 106-07, September 2007, Range Commanders Council, U.S. Army White Sands Missile range, New Mexico 88002. Page 2-12. Via the Internet at https://wsmrc2vger.wsmr.army.mil/rcc/indexmain.htm.

2/ Telemetry Applications Handbook, Document 119-06, May 2006, Range Commanders Council, U.S. Army White Sands Missile range, New Mexico 88002. Page 2-178. Via the Internet at https://wsmrc2vger.wsmr.army.mil/rcc/indexmain.htm.

3/ *Protection Criteria for Telemetry Systems in the Aeronautical Mobile Service and Mitigation Techniques to Facilitate Sharing with Geostationary Broadcasting-Satellite and Mobile-satellite Services in the Frequency Bands 1452-1525 MHz and 2310-2360 MHz,* Recommendation ITU-R M.1459, 2000, Section 2.1. Via the Internet at /www.itu.int.

5 degrees, MBANS signals propagating along the horizontal would be received with antenna gains less than 0 dBi. This antenna gain assumption is considered highly conservative given the increased directionality of the sidelobe patterns at 2360 MHz, as opposed to those for the 1452-1525 MHz band given in the ITU Recommendation. In addition, MBANS devices will be distributed in azimuth relative to the telemetry receive dish antenna such that antenna gain values well below 0 dBi are encountered in side and back lobes. Table 2 includes the assumed parameters for the aeronautical telemetry receiver. The noise figure parameter is conservatively chosen to reflect a system with favorable sensitivity, based on representative elements from the RCC telemetry application handbook. 4/

Table 2 – Radio Receiver Characteristic Assumptions

Victim Receiver Category	Receiver Bandwidth (MHz)	Receive Antenna Gain (dBi)	Center Frequency (MHz)	Noise Figure (dB)
1 – Amateur FS TV, high-rate data	6.0	-6.0	2393.0	7.0
2 – Amateur Packet, control/auxiliary	0.005	-3.0	2399.5	15.0
3 – Aeronautical telemetry	10.0	0.0	2377.5	2.0

III. INTERFERENCE ANALYSIS

A. Methodology

An interference link budget was developed to calculate the interference levels that would result from the MBANS transmission at the proposed, maximum radiated carrier power (EIRP = 0 dBm) at the center frequency for each of the radio categories of Table 2. Interference levels are evaluated at the victim receiver over various separation distances spanning 1 to 10,000 meters.

The results of this analysis are conservative in their inclusion of propagation loss and attenuation due to terrain, building structures, and body-worn antennas. Attenuation from internal and external building walls, as well as from body-worn antenna polarization and misalignment, would likely contribute more than 12 dB of attenuation, reducing the likelihood of interference. Propagation of signals into buildings at 2300 MHz showed average penetration loss

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4/ Telemetry Applications Handbook, Document 119-06, May 2006, Range Commanders Council, U.S. Army White Sands Missile range, New Mexico 88002. Page 2-178. Via the Internet at https://wsmrc2vger.wsmr.army.mil/rcc/indexmain.htm.

of 12.8 dB with standard deviation of 4 to 6 dB. 5/ MBANS devices will typically be found indoors, within hospital, physician's office or home environments.

This analysis assumes co-channel interference between the MBANS transmitter and the victim radio whose tuning range permits overlap with one or more MBANS channels. The resulting separation distances are based on the conservative assumption that the incumbent links are operating with virtually zero margin. In the frequent case where the incumbent links have greater excess margin the required separation would be even less.

Reference is made to the interference calculations presented in spreadsheet format in Table 3. Calculations are performed in logarithmic form to simplify the math and follow normal engineering practice.

The first two columns, [A] and [B], specify the victim radio category and center frequency. Column [C] contains the proposed, maximum effective isotropic radiated power for the MBANS transmitter, which is a constant 0 dBm (1 milliwatt) value. Column [D] lists the separation distance between MBANS transmitter and the victim receiver, in meters.

Propagation path loss is calculated in column [E] as $10*n*LOG_{10}(4\ \ df/c)$, where path loss exponent $n = 2.4$, d is the separation distance of column [D], f is the frequency from column [B] and c is the speed of light, $3x10^8$ meters/second. Path loss differs by approximately 0.1 dB over the frequencies of interest. The use of $n = 2.4$ for path loss exponent, rather than $n = 2.0$ of free space, represents a realistic assumption based on empirical studies found in the engineering literature. Experimental path loss measurements for the 2.4 to 2.5 GHz MMDS/ISM band were collected and published by Motorola and Sprint 6, 7/ These experimental data sets were collected in suburban environments at distances of meters to tens of kilometers.

Column [F] shows the antenna gain, in dBi, at the victim receiver for the incident MBANS signal. The MBANS signal level, in dBm, at the victim receiver is calculated in column [G] as the linear combination of columns [C], [E], and [F] :

MBANS signal (dBm) = EIRP (dBm) – Path Loss (dB) + Receive Antenna Gain (dBi).

The MBANS interfering signal levels, shown in column [G], represent the full 1 milliwatt power of the MBANS transmitter over its 1 MHz bandwidth. However, the victim receiver categories considered utilize front-end filtering of larger and smaller extent. The victim radio receiver will

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5/ "Estimating Coverage of Radio Transmission Into and Within Buildings at 900, 1800 and 2300 MHz", A. F. De Toledo, A. Turkmani and J.D. Parsons, IEEE Personal Communications, April 1998, pages 40-47.

6/ "Microwave Propagation Characteristics In The MMDS Frequency Band" by J.W. Porter and J.A. Thewatt, 2000 IEEE International Conference on Communications, Vol. 3, pages 1578-1582.

7/ "Path Loss Correlation Between PCS and MMDS/ISM Bands in Suburban Morphology – An Empirical Model" by O.W. Ata and H. Garg, IEEE Antennas and Propagation Society International Symposium, 2004, Vol. 4, pages 3649-3652.

intercept a level of interference power corresponding to the ratio of its band pass bandwidth to the full bandwidth occupied by the MBANS transmission. Column [I] reflects the MBANS interference within the victim receiver front end as:

$$\text{MBANS signal (dBm)} + 10*\text{LOG}_{10}[\min(1, BW_{victim}/1\text{ MHz})],$$

Where min() denotes the minimum operation and BW_{victim} is taken from the assumed category parameters of Table 2 and found in column [H]. It is clear that for radio categories 1 and 3, the victim receiver bandwidth is wider than the MBANS signal such that the entire MBANS interference is observed within the victim receiver front end. The narrowband response of radio category 2 limits a significant portion of the incident MBANS interfering signal.

The aggregate duty cycle, considering multiple MBANS transmitters comprising a single network on a specific patient was described above as being less than 25%. This duty cycle is reflected in column [J] which is simply a reduction in the average power of the incident MBANS power. By virtue of the duty cycle, the relative MBANS signal level of column [I] is reduced by the factor $10*\text{LOG}_{10}(0.25) = -6.02$ dB.

The resulting interference power level from the MBANS transmitter can be compared to the thermal noise at the victim radio receiver to obtain the interference-to-noise ratio. The receiver's internal thermal noise is a function of its noise figure or system temperature. The assumed noise figures for the victim radio categories listed in Table 2 are repeated in column [K]. The victim receiver noise floor level is calculated in column [L] according to $N = k + 10*\text{LOG}_{10}(TB) + NF$, where k is Boltzmann's constant = -198.6 dBm/(°K-Hz), T is the system noise temperature = 290 Kelvin, B is the victim receiver bandwidth from column [H], and NF is the victim noise figure in dB from column [K]. The ratio of MBANS interference to victim receiver noise floor is given in column [M] and is calculated as a simple difference between columns [J] and [L].

B. Results

The results in column [M] of Table 3 show that at ranges greater than or equal to 100 meters the interference level from MBANS transmissions would be at least -8, -6 or 0 dB relative to the noise floor of amateur FS-TV, amateur packet/control and aeronautical telemetry receivers, respectively. Amateur FS-TV and packet/control services will observe MBANS transmissions equal to their noise floor at separations of 42.8 and 55.7 meters, respectively. Therefore, the victim radio receiver cannot discern the presence of the MBANS signals when separated by at least 100 meters.

At a separation distance of 1000 meters, the interference level from MBANS transmissions would be at least 32, 30, 24 dB below the noise floor of amateur FS-TV, amateur packet/control and aeronautical telemetry receivers, respectively. The estimated interference-to-noise ratio of –24 dB is well below the value of –2.68 dB recommended by the ITU-R. 8/ This ITU-R M.1459

8/ *Protection Criteria for Telemetry Systems in the Aeronautical Mobile Service and Mitigation Techniques to Facilitate Sharing with Geostationary Broadcasting-Satellite and Mobile-satellite Services in the Frequency Bands 1452-1525 MHz and 2310-2360 MHz,* Recommendation ITU-R M.1459, 2000, Section 2.2.4.

document recommends –8.13 dB I/N for terrestrial interference sources in addition to –4.15 dB from BSS satellites. As there are no BSS satellites present in the proposed 2360-2400 MHz band, we consider the composite interference of –2.68 dB I/N as a criteria for coexistence with aeronautical telemetry receivers. A separation distance of only 129.3 meters is sufficient to reduce MBANS transmission levels to the ITU-R M.1459 recommended I/N level. Nevertheless, a separation distance of only 218.2 meters would reduce MBANS transmission levels to the –8.13 dB I/N level. It is highly unlikely that a MBANS system will be in operation within 219 meters of an aeronautical telemetry receiver because telemetry ground installations are typically large and well-controlled and the location of airborne vehicle testing "is often restricted to areas over water or uninhabited land in order to preclude danger to life or property in case of catastrophic failure of the vehicle being tested…" 9/

As a result, these interference calculations are considered to be overly conservative. MBANS interference to amateur and aeronautical telemetry receivers operating within 2360 to 2400 MHz would likely be imperceptible at separation distances of 100 meters or more.

In the event that such collocation does exist, the interference presented by the MBANS transmitter could be mitigated by adjusting the orientation or alignment of the victim radio receiver antenna or increasing the distance between the MBANS and victim receiver. GE Healthcare provided an engineering analysis which indicates that, given collocation of MBANS and high power, long range devices, MBANS devices would observe interference at a greater separation distance than the high power, long range devices. 10/ The MBANS devices would then utilize their contention-based protocols and dynamic frequency selection within the proposed 40 MHz frequency band to reduce the risk of harmful interference to and from nearby, primary service operations.

9/ *Protection Criteria for Telemetry Systems in the Aeronautical Mobile Service and Mitigation Techniques to Facilitate Sharing with Geostationary Broadcasting-Satellite and Mobile-satellite Services in the Frequency Bands 1452-1525 MHz and 2310-2360 MHz,* Recommendation ITU-R M.1459, 2000, Section 2.2.2

10/ Reply Comments of GE Healthcare, ET Docket No. 06-135 (filed Dec. 4, 2006) at Appendix A.

Table 3 – Coexistence Analysis for MBANS with Aeronautical and Amateur Receiver Categories, (Path Loss n=2.4)

[A] VICTIM RCVR CATEGORY	[B] FREQ. (MHz)	[C] MBANS EIRP (dBm)	[D] MBANS AND VICTIM DISTANCE (meters)	[E] PATH LOSS, n=2.4 (dB)	[F] RECEIVE ANTENNA GAIN (dBi)	[G] MBANS INTERFERENCE AT VICTIM (dBm)	[H] VICTIM RECEIVER BANDWIDTH (MHz)	[I] MBANS INTERFERENCE IN VICTIM FRONT END RF CHANNEL (dBm)	[J] NET INTERFERENCE TO VICTIM RECEIVER (dBm)	[K] VICTIM RECEIVER NOISE FIGURE (dB)	[L] VICTIM RECEIVER NOISE FLOOR (dBm)	[M] MBANS I/N RATIO (dB)
1	2393.0	0	1	48.02	-6.0	-54.02	6.0	-54.02	-60.05	7.0	-99.19	39.15
1	2393.0	0	10	72.02	-6.0	-78.02	6.0	-78.02	-84.05	7.0	-99.19	15.15
1	2393.0	0	42.8	87.17	-6.0	-93.17	6.0	-93.17	-99.19	7.0	-99.19	0.00
1	2393.0	0	100	96.02	-6.0	-102.02	6.0	-102.02	-108.05	7.0	-99.19	-8.85
1	2393.0	0	1,000	120.02	-6.0	-126.02	6.0	-126.02	-132.05	7.0	-99.19	-32.85
1	2393.0	0	10,000	144.02	-6.0	-150.02	6.0	-150.02	-156.05	7.0	-99.19	-56.85
2	2399.5	0	1	48.05	-3.0	-51.05	0.005	-74.06	-80.08	15.0	-121.99	41.90
2	2399.5	0	10	72.05	-3.0	-75.05	0.005	-98.06	-104.08	15.0	-121.99	17.90
2	2399.5	0	55.7	89.95	-3.0	-92.95	0.005	-115.96	-121.98	15.0	-121.99	0.00
2	2399.5	0	100	96.05	-3.0	-99.05	0.005	-122.06	-128.08	15.0	-121.99	-6.10
2	2399.5	0	1,000	120.05	-3.0	-123.05	0.005	-146.06	-152.08	15.0	-121.99	-30.10
2	2399.5	0	10,000	144.05	-3.0	-147.05	0.005	-170.06	-176.08	15.0	-121.99	-54.10
3	2377.5	0	1	47.96	0.0	-47.96	10.0	-47.96	-53.98	2.0	-101.98	48.00
3	2377.5	0	10	71.96	0.0	-71.96	10.0	-71.96	-77.98	2.0	-101.98	24.00
3	2377.5	0	100	95.96	0.0	-95.96	10.0	-95.96	-101.98	2.0	-101.98	0.00
3	2377.5	0	129.3	98.63	0.0	-98.63	10.0	-98.63	-104.65	2.0	-101.98	-2.68
3	2377.5	0	218.2	104.09	0.0	-104.09	10.0	-104.09	-110.11	2.0	-101.98	-8.13
3	2377.5	0	1,000	119.96	0.0	-119.96	10.0	-119.96	-125.98	2.0	-101.98	-24.00
3	2377.5	0	10,000	143.96	0.0	-143.96	10.0	-143.96	-149.98	2.0	-101.98	-48.00